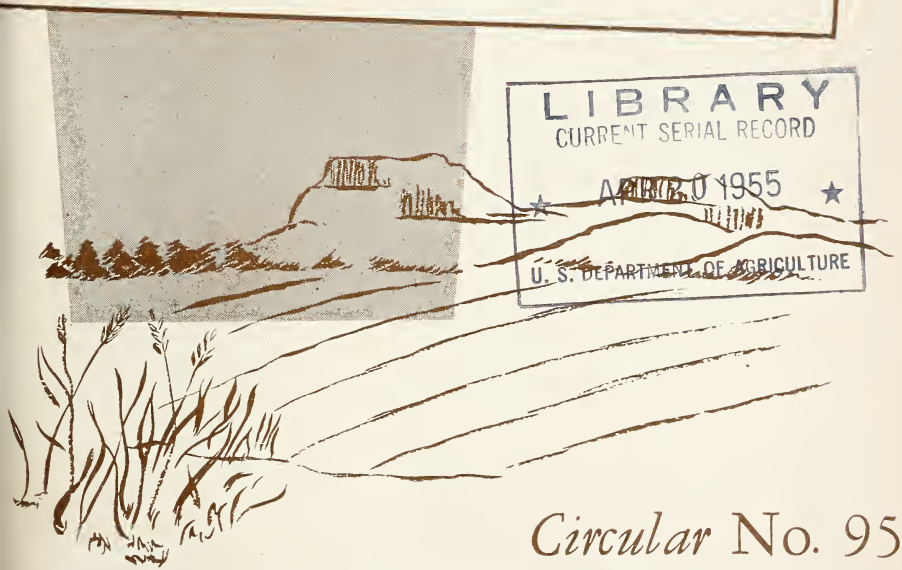
RANGE SEEDING

in the Ponderosa Pine Zone in Colorado

By A. C. Hull, Jr., and W. M. Johnson



Circular No. 953
U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

Washington, D. C. Issued February 1955

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.—Price 20 cents

Range Seeding in the Ponderosa Pine Zone in Colorado

By A. C. HULL, JR., and W. M. JOHNSON, *Range Conservationists,*[1]
Rocky Mountain Forest and Range Experiment Station[2]

INTRODUCTION

Successful range seeding can quickly restore grass on depleted openings or parks in the ponderosa pine [3] zone in Colorado. Research results and experience from numerous seedings in the ponderosa pine zone are summarized in this circular to guide ranchers and range managers in seeding ranges successfully.

On an estimated half-million acres of productive range of high potential in the ponderosa pine zone of Colorado, forage values have been virtually destroyed by excessive grazing or previous cultivation. These grazing lands are now producing very little forage, and some are eroding. Restoration through natural revegetation may require decades, but by seeding adapted grasses full forage production and soil stabilization can be accomplished in 2 to 3 years.

Restoration through natural revegetation is often feasible and most economical, but where the best forage species have been eliminated, this method of improvement is very slow. One study, for example, has shown that 15 to 25 years are necessary for natural revegetation to produce the mixed perennial grass and forb stage on plowed and abandoned lands under good grazing management (*8*).[4] Good stand development of the original native bunchgrasses on such land requires a much longer time. One field on the Manitou Experimental Forest abandoned and grazed, sometimes heavily, for 72 years has only a partial cover of original native grasses.

Seeding is usually justified where there are not enough desirable plants to restore a good cover within a reasonable time, and where the site is suitable for introducing productive species. Often the benefits from rapid improvement through seeding extend beyond the treated areas. The extra forage obtained on selected areas can reduce the grazing pressure on adjacent range and thus permit improvement through increased vigor and natural revegetation.

---

[1] The authors thank staff members of Colorado A. & M. College and the Agricultural Conservation Program Service for part of the information used in this circular; and the Soil Conservation Service for supplying seed of hard-to-get species.

[2] Forest Service, U. S. Department of Agriculture, with headquarters at Colorado A. & M. College, Fort Collins, Colo.

[3] Common and botanical names of the native species mentioned are listed on p. 39. Scientific names of reseeded species are found in table 2, p. 12.

[4] Italic numbers in parentheses refer to Literature cited, p. 39.

By reseeding, the period when green nutritious forage is available can be prolonged and tends to balance the yearlong forage supply. For example, early growing grasses can be seeded for early spring grazing, grasses that remain green during the summer can be used for summer grazing, and grasses that grow readily because of early fall rains or that cure well on the stem can be used for fall or winter grazing. At the Manitou Experimental Forest in Colorado, crested wheatgrass is ready for grazing from 3 to 4 weeks, and Russian wildrye from 6 to 8 weeks, before the native grasses on the adjacent ranges can be grazed (fig. 1). Reports from Utah indicate that crested wheatgrass in that area can be successfully grazed from 2 to 3 weeks earlier than native ranges (2). Throughout a large part of Colorado a relatively small seeded area can often supply the early spring forage so much needed to balance the yearlong forage supply.

In addition to these forage benefits, reseeded grass produces many deep, fine roots that hold the soil in place, and the roots and the accumulated litter aid absorption of rain by the soil. The replacement of thin weedy stands with good ones of perennial grass reduces the siltation damage to reservoirs and irrigation systems in the valleys below them. These watershed and range values combine with those of timber to make the ponderosa pine lands important in Colorado's economy.

The ponderosa pine zone covers approximately 4 million acres in the Front Range of the Colorado Rockies at elevations of 5,500 to 9,500 feet and in southwestern Colorado at 6,500 to 10,000 feet.

F-465960

FIGURE 1.—Crested wheatgrass is usually ready for grazing by May 1 at the Manitou Experimental Forest, whereas native grasses on the adjacent range are not tall enough to graze until June 1. This seeded area produced an average of 1,575 pounds of grass per acre each year, 1948–53.

Average annual precipitation varies in different parts of the zone from about 22 inches in the higher-elevation areas to as little as 11 inches in the lower-elevation fringe areas. Half or more of the annual precipitation ordinarily falls during the April–September period, July and August usually being the highest rainfall months. Juniper, pinyon pine, oak, and big sagebrush are common subtypes in the lower portion of the zone, and lodgepole pine, Douglas-fir, and aspen are prevalent at higher elevations.

Parks, valleys, meadows, and open timber areas within the type normally support good stands of grass and are important producers of forage for livestock. Main grasses are Arizona fescue and mountain muhly, with many other species, such as danthonia, little bluestem, blue grama, and western wheatgrass. Ranges consisting mostly of openings and open timber provide one cow-month of grazing for every 4 acres when in good to excellent condition (fig. 2). Many of the openings, however, have been farmed and abandoned, or have been badly overgrazed. They now produce only low-value stands of annual and perennial weeds and grasses, such as slimstem muhly, sleepygrass, trailing fleabane, and fringed sagebrush. These lands are of little value for grazing. Successful seeding of these abandoned lands and depleted ranges has often increased the yields so that 1 acre of a good stand under good management furnishes a month's grazing for a cow (fig. 3).

F-447578

FIGURE 2.—Ponderosa pine-bunchgrass range in good condition supports good stands of grasses, such as Arizona fescue and mountain muhly. Four acres of such range will on the average support a cow for a month.

BASIS OF INFORMATION

This circular reports on 28 experimental seedings and 391 other observed range seedings of various kinds in the ponderosa pine type. The 28 experimental seedings are at 20 locations (fig. 4). Site characteristics of each location are summarized in table 1. The types of

experimental seedings and the main steps in conducting the work were as follows:

1. One hundred and twenty-one species, varieties, and strains from many seed sources were tested for adaptability to soil and climatic conditions in a preliminary row-plot study. Plots were hand-seeded and kept free of weeds but were grown without irrigation or fertilization.

2. Thirty-five of the species that appeared to have promise were seeded on 465 plots in 18 studies under range conditions, where they competed with weeds and invading plants. Those that showed up well were then used for range seedings.

3. From 7 studies on 360 plots the best methods of seeding were determined. These studies also provided information on species adaptability. Likewise, other species studies were useful for evaluating seeding methods.

4. Four species, alone or in mixtures, were seeded on two 50-acre grazing study areas. Although primarily used to determine grazing values of the 4 species, the 2 areas also provided data on species and methods of seeding.

F-435729, 476600

FIGURE 3.—Formerly cultivated and abandoned land in the ponderosa pine zone near the Manitou Experimental Forest: *A*, This area grows only fringed sagebrush and low-value weeds and grasses. Only 20 pounds of palatable herbage is produced on an acre; *B*, a similar area seeded to a mixture of crested wheatgrass, smooth brome, and yellow sweetclover in 1946 has averaged 1,887 pounds of air-dry herbage per acre, 1947–53. The sweetclover was not prominent after the second year.

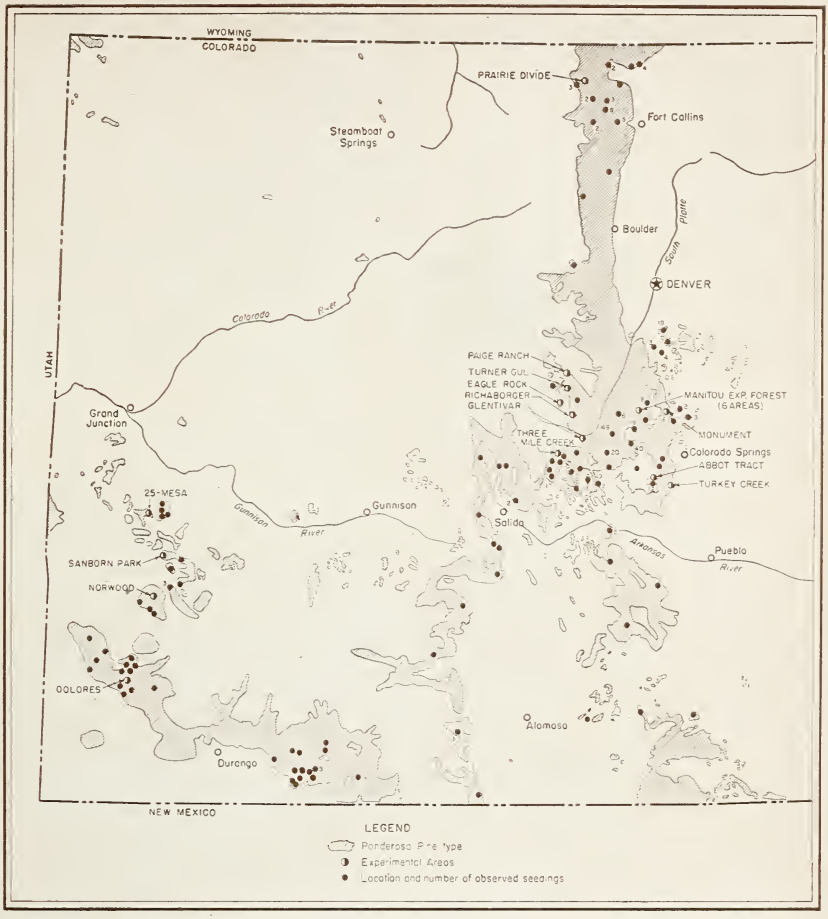


FIGURE 4.—Generalized boundaries of the ponderosa pine type in Colorado with locations of the 20 experimental areas and the 391 observed range seedings.

Information from these 28 experimental seedings and from the 391 observed range seedings has been evaluated in arriving at the recommendations made in this circular. Although the recommendations based on these seedings are mainly for the ponderosa pine zone in Colorado, they will undoubtedly be helpful for adjacent zones and for ponderosa pine lands in adjacent States.

WHERE TO SEED

The open areas in the ponderosa pine zone with good soil and moisture and few valuable forage plants usually offer excellent seeding opportunities and should receive first attention in a seeding program. They are mostly occupied by such plants as annual or perennial forbs, sleepygrass, slimstem muhly, cheatgrass brome, blue grama, and big

TABLE 1.—*Site characteristics of the 20 experimental areas*

Planting sites	Elevation	Annual precipitation	Soil characteristics	Other site characteristics and dominant native vegetation
	Feet	*Inches*		
Abbot Tract	10, 000	20	Rocky and gravelly, sandy loam from granite. Low fertility, low organic matter, and low moisture-holding capacity.	Badly eroding 20 percent south slope growing annual and perennial weeds.
Richaborger and Eagle Rock	9, 700	12	Rocky, sandy loam from granite-gneiss. Low fertility, low organic matter, and moderate moisture-holding capacity.	Depleted rangeland growing fringed sagebrush, slimstem muhly, and blue grama.
Glentivar	9, 500	11	Rocky and gravelly, sandy loam from granitic schist. Low organic matter. Moderate fertility and moderate moisture-holding capacity.	Depleted rangeland growing fringed sagebrush, slimstem muhly, and blue grama.
Paige Ranch and Turner Gulch.	9, 500	13	Sandy loam from granite-gneiss. Low fertility, low organic matter, and moderate moisture-holding capacity.	Depleted rangeland growing fringed sagebrush and slimstem muhly.
Three-Mile Creek	9, 400	13	Rocky loam from andesite. Moderate organic matter, high moisture-holding capacity, and high fertility.	Depleted rangeland growing fringed sagebrush, slimstem muhly, and blue grama.
Prairie Divide	8, 000	18	Rocky, loamy sand from glacial till. Low fertility, low organic matter, and low moisture-holding capacity.	Depleted rangeland growing fringed sagebrush, slimstem muhly, and blue grama.
Sanborn Park	8, 000	17	Sandy loam from Dakota sandstone. Low fertility, low organic matter, and moderate moisture-holding capacity.	Scattered big sagebrush 16 inches tall with some grass and weeds in understory.
Norwood	8, 000	17	Sandy loam from sandstone. Moderate fertility, moderate organic matter, and low moisture-holding capacity.	Depleted big sagebrush opening with poor stand of western wheatgrass and other plants.
Dolores	8, 000	16	Sandy loam from sandstone. Low fertility, low organic matter, and low moisture-holding capacity.	Depleted opening with annual and perennial weeds and some western wheatgrass.

25-Mesa [1]	7,800	17	Sandy loam from Dakota sandstone. Low fertility, low organic matter, and moderate moisture-holding capacity.	Dense big sagebrush, 24 inches tall, with scattered grass and weed understory.
Missouri Gulch [1] (at Manitou Experimental Forest).	7,700	16	Gravelly, coarse, sandy loam from granite. Very low fertility, low organic matter, and low moisture-holding capacity.	Depleted, eroding 30 percent south slope growing annual and perennial weeds.
Headquarters field and nursery; Sinclair, Corral,[1] and West fields [1] (at Manitou Experimental Forest).	7,600	16	Coarse, sandy loam from granite. Low fertility, low organic matter, and moderate moisture-holding capacity.	Abandoned farmland growing fringed sagebrush, trailing fleabane, and sleepygrass.
Monument [1]	7,000	18	Sandy loam from granite. Low fertility, low organic matter, and moderate moisture-holding capacity.	Opening in oak, growing sleepygrass, blue grama, and weeds.
Turkey Creek [1]	6,000	14	Sandy loam from mixed granite and sedimentaries. Low fertility, low organic matter, and low moisture-holding capacity.	Depleted rangeland, growing slimstem muhly, blue grama, and weeds.

[1] Two or more seedings.

219369—55——2

sagebrush. Abandoned fields that had formerly been cultivated are especially well adapted to seeding. Aspen stands that contain little herbaceous vegetation are also good possibilities.

Precipitation in the ponderosa pine zone is normally adequate for successful seeding. Even some dry sites at the lower edge of the zone have been successfully seeded, especially where summer-fallow practices have been followed. But poor moisture conditions often prevail at the lower elevations, which make reseeding results erratic. Until further information is available, reseeding on these dry sites should be done on an experimental basis only.

Soils in the ponderosa pine zone vary greatly in texture, fertility, organic matter, and moisture-holding capacity. Luxuriant vegetation, even though it be low-value grass, weeds, or brush, usually indicates fertile soil with sufficient moisture to produce good stands of seeded species. These more favorable sites should be seeded first. Greater forage increases will be obtained on such sites, and the information gained will help in judging the seeding possibilities of the poorer lands. Steep south-facing slopes, which are drier and have poorer soils than north slopes or more level sites, should not generally be seeded until better species and methods for seeding such areas have been determined.

Where enough desirable forage plants are present to increase and form a good stand within a reasonable time through natural seeding and good management, artificial seeding is usually not justified. Often an area is grazed so closely that the good native grasses are low in vigor and are hardly recognizable. To accomplish natural recovery, grazing must be sufficiently light to allow seed production and seedling establishment. Studies showed that when 35 to 40 percent of the current growth of the best grasses was utilized each year, native range vegetation improved, production increased, and economic returns were higher than when grazing was heavier (*11*).

WHEN TO SEED

Follow the rule of seeding just before a period when enough moisture can be expected for seed germination and seedling growth during 1 to 2 months of growing weather. At the Manitou Experimental Forest, fall or early spring seedings in the row plots showed about equal success. Some, such as the gramas and certain legumes, produced slightly better stands from seeding in April than in October.

Along the Front Range, seeding from late September to November is most dependable. Fall is the most practical time for large-scale range seedings, because the planting season is relatively long and storm-free. In southwestern Colorado, where good late-summer precipitation can be expected, seeding in early August allows plants to become established in the fall.

Spring seedings are often successful, especially on areas where seeding can be done early enough to take advantage of favorable spring precipitation, and the young plants can grow sufficiently to withstand the summer drought. Spring seeding is best for warm-season species such as grama grasses. Seedings made after April are less likely to succeed.

A firm seedbed is a necessity for spring seeding because the soil may dry out quickly if it is loose. If a loose seedbed is sown in the fall, storms in fall and winter usually help it to settle before the seed germinates the following spring.

As previously stated, the ponderosa pine zone normally receives sufficient precipitation to make reseeding successful. However, wide variations occur in most localities, and in dry years precipitation may be inadequate. This is illustrated by the records at Durango and at the Manitou Experimental Forest (figs. 5 and 6). Rainfall at these two locations is representative of that in the two major geographic divisions of the ponderosa pine zone of Colorado—the Front Range in the central part of the State, and southwestern Colorado. At the Manitou Experimental Forest, annual precipitation varied from 8 to 26 inches, and at Durango from 9 to 34 inches. Summer precipitation is also variable. At Manitou Experimental Forest the months of June, July, and August, which normally have 7.5 inches of precipitation, may have over 13 inches as in 1945 and 1947, or only 3 inches as in 1939 and 1951. However, because of these fluctuations and the erratic distribution of precipitation, the chances of success are reduced during dry years, and failures can be expected occasionally even on the best sites.

At Manitou because of lack of rain the period 1950–52 was a severe survival test for both native and seeded grasses. With good seedbed preparation, most experimental seedings were successful even during this dry period.

WHAT TO SEED

Growth characteristics of the different species and their adaptability to climate and soil conditions on the seeded area must be considered in order to insure proper selection of species (*9*). Species and strains should be able to withstand invasion by undesirable plants and to maintain themselves and prevent erosion under moderate grazing. Stands must be easily established. Seed should be available at a reasonable price. The most valuable species produce a large volume of forage that can be advantageously utilized at the season when the area is to be grazed.

Species Tests

Preliminary Tests (Row Plots)

A large number of species have been screened for general adaptation to conditions in the ponderosa pine zone. The majority of these have also been tested in other regions (*3*, *14*, *17*). Since 1945, a total of 121 species and strains have been seeded, both spring and fall, in row plots at the Manitou Experimental Forest headquarters (fig. 7). Included in the tests were 85 different kinds of grasses, 23 broadleaved herbs (19 of which are legumes), and 13 shrubs and small trees. At least once each year all plantings were rated from excellent to failure, and as to the relative success of stand establishment and plant vigor. Also noted were season of growth, seeding habits, and spread by seed or rhizomes. Success ratings in 1953, when some of the plantings were 8 years old, are shown in table 2.

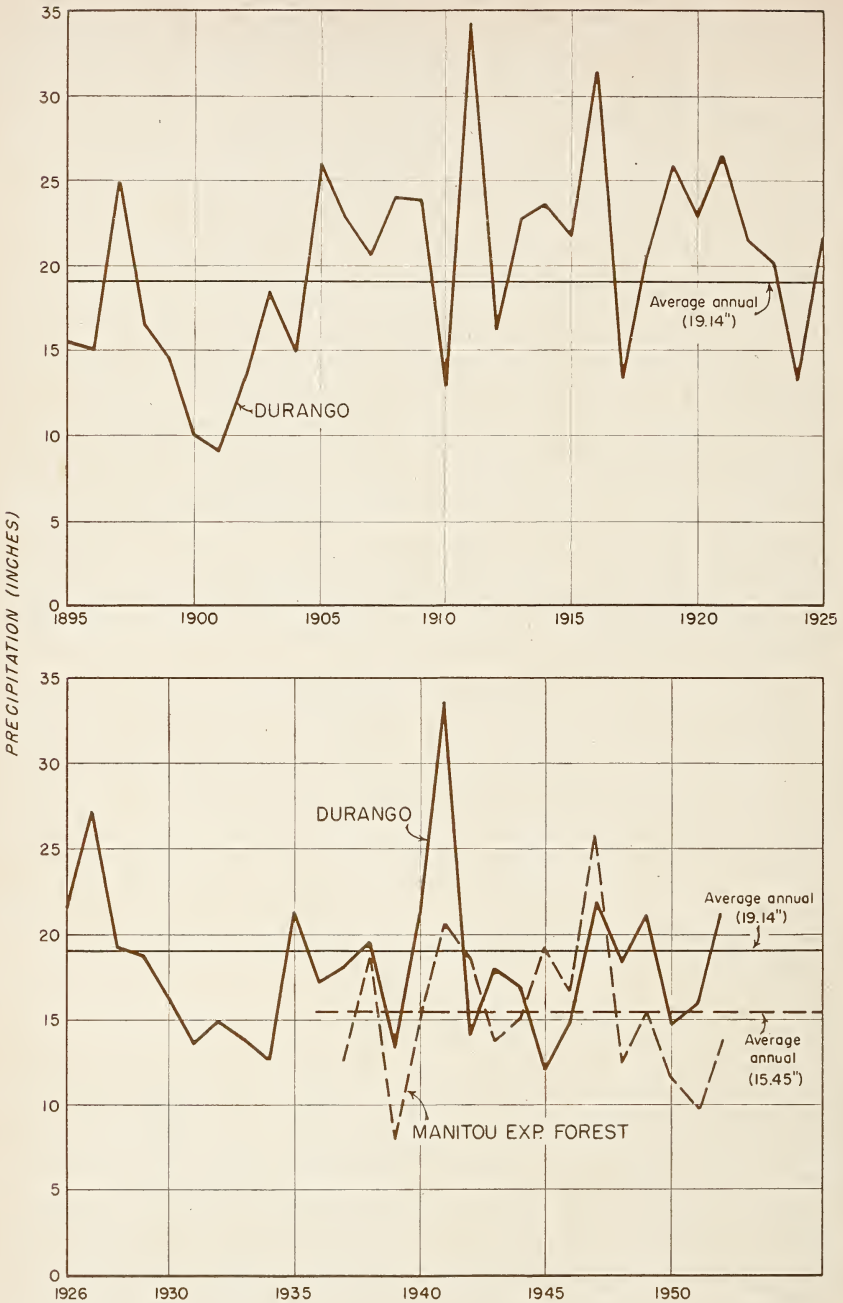


FIGURE 5.—Yearly and average annual precipitation at Durango, Colo., 1895–1952, and at the Manitou Experimental Forest, 1937–52.

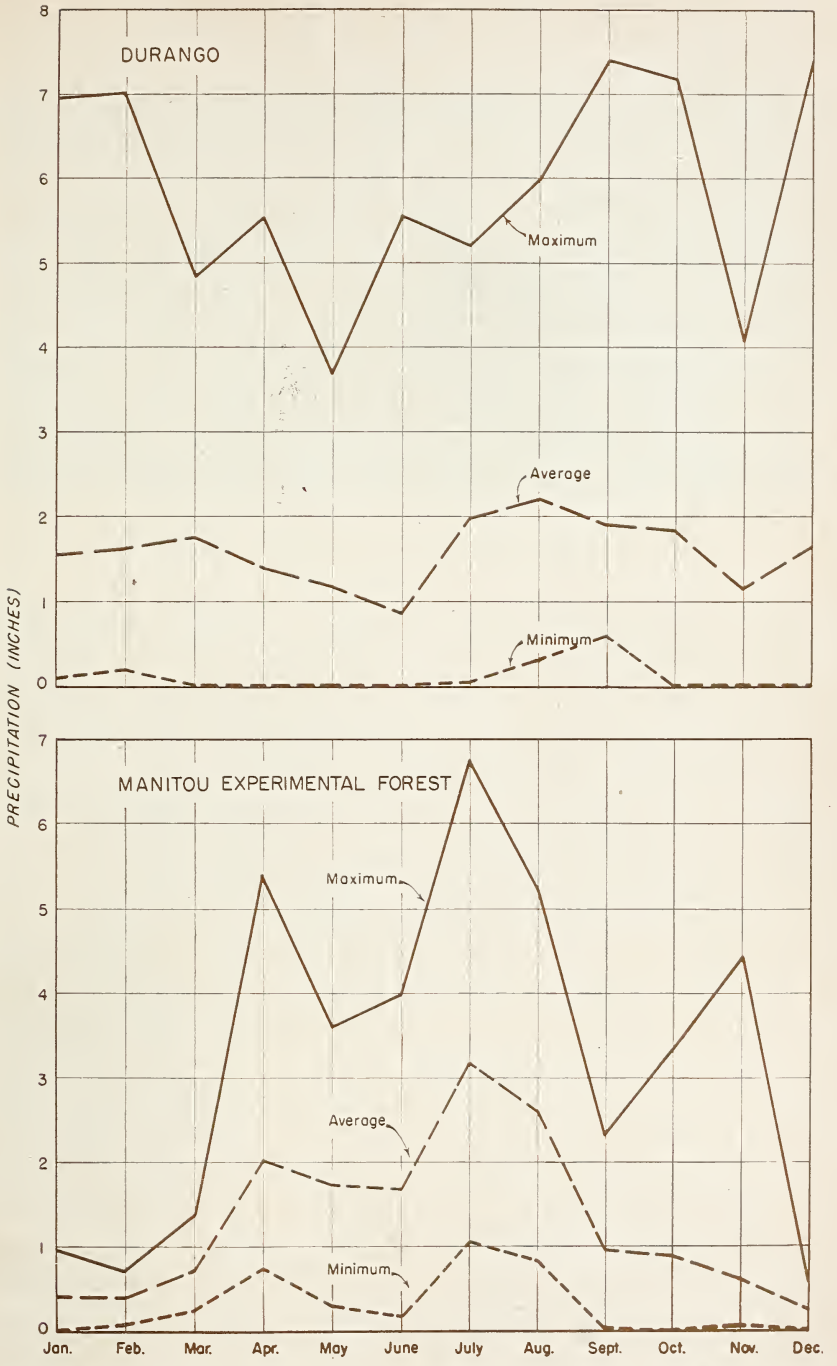


FIGURE 6.—Maximum, minimum, and average monthly precipitation at Durango, Colo., 1895–1952, and at the Manitou Experimental Forest, 1937–52.

F-465967

FIGURE 7.—One hundred and twenty-one different kinds of grasses, forbs, and shrubs were seeded in row plots, fall and spring, 1945–50.

TABLE 2.—*Success ratings* [1] *in 1953 of 121 species, varieties, and strains seeded in preliminary row tests at Manitou Experimental Forest, 1945–50*

Scientific and common name	Date planted		Rating [1] of seeded stands planted	
	In fall	In spring	In fall	In spring
Agropyron bakeri, Baker wheatgrass	1945	1946	F	F
A. ciliare, wheatgrass	1948	1949	[2] O	[2] O
A. cristatum, Fairway crested wheatgrass	1945	1946	E	E
A. cristatum var., rhizomatous crested wheatgrass	1945	1946	E	E
A. dasystachyum, thickspike wheatgrass	1946	1947	E	G
A. desertorum, Standard crested wheatgrass (desert wheatgrass)	1945	1946	E	E
	[3] 1946	1947	E	E
A. elongatum, tall wheatgrass	1945	1946	[2] O	[2] O
A. inerme, beardless wheatgrass	1945	1946	E	G
A. intermedium, intermediate wheatgrass	1945	1946	E	E
A. popovii, wheatgrass	1949	1950	F	E
A. pungens, stiffleaf wheatgrass	1945	1946	O	F
A. repens, quackgrass	1946	1947	E	E
A. riparium, streambank wheatgrass	1948	1949	O	O
A. semicostatum, drooping wheatgrass	1945	1946	[2] O	[2] O
A. sibiricum, Siberian wheatgrass	1945	1946	E	E
A. smithii, western wheatgrass	1945	1946	G	E
A. spicatum, bluebunch wheatgrass	1945	1946	G	G
A. subsecundum, bearded wheatgrass	1945	1946	E	G
A. trachycaulum, slender wheatgrass	1945	1946	E	G
	1946	1947	E	E
A. trichophorum, pubescent wheatgrass	1945	1946	G	G
Agrostis alba, redtop	1945	1946	[2] O	[2] O

See footnotes at end of table.

TABLE 2.—*Success ratings* [1] *in 1953 of 121 species, varieties, and strains seeded in preliminary row tests at Manitou Experimental Forest, 1945–50*—Continued

Scientific and common name	Date planted		Rating [1] of seeded stands planted	
	In fall	In spring	In fall	In spring
Agrostis tenuis, Colonial bent	1948	1949	O	E
Andropogon ischaemum, Turkestan bluestem	1945	1946	[2] O	[2] O
A. scoparius, little bluestem	1945	1946	E	E
Arctostaphylos uva-ursi, bearberry	1946	1947	O	O
Arrhenatherum elatius var. *bulbosum*, tuber oatgrass	1945	1946	[2] O	[2] O
Artemisia abrotanum, oldman wormwood	------	1949	------	E
A. tripartita, threetip sagebrush	1949	1950	O	O
Astragalus chinensis, milkvetch	1948	1949	O	F
A. cicer, chickpea milkvetch	1946	1947	[4] F	[4] P
A. falcatus, sicklepod milkvetch	1948	1949	E	G
A. mortonii, Morton loco	1946	1947	[4] O	[4] O
Atriplex canescens, fourwing saltbush	1945	1946	O	O
Balsamorhiza sagittata, arrowleaf balsamroot	1946	1947	O	O
Blepharoneuron tricholepis, pine dropseed	1946	1947	O	[2] O
Bouteloua curtipendula, sideoats grama	1945	1946	O	G
B. gracilis, blue grama	1945	1946	O	E
Bromus anomalus, nodding brome	1945	1946	[2] O	F
B. carinatus var. *marginatus*, mountain brome	1945	1946	[2] O	[2] O
B. carinatus var. *polyanthus*, mountain brome	1945	1946	[2] O	[2] O
B. carthariticus, rescue brome	1945	1946	[2] O	[2] O
B. erectus, meadow brome	1945	1946	E	E
B. frondosus, weeping brome	1946	1947	F	F
B. inermis, smooth brome	1945	1946	E	E
	1946	1947	E	E
B. inermis, smooth brome (hort. var. ACHENBACH)	1945	1946	E	E
B. inermis, smooth brome (hort. var. WASHINGTON)	1945	1946	E	E
B. purgans, Canada brome	1946	1947	P	F
B. tomentellus, subalpine brome	1948	1949	O	O
Buchloë dactyloides, buffalograss	1946	1947	E	E
Caragana aborescens, Siberian peashrub	1946	1947	E	E
Celtis reticulata, net leaf hackberry	1946	1947	O	O
Cercocarpus montanus, mountain cercocarpus	1946	1947	O	O
Dactylis glomerata, orchardgrass	1945	1946	[2] O	[2] O
Danthonia intermedia, timber danthonia	1946	1947	O	E
Elymus canadensis, Canada wildrye	1945	1946	G	P
E. chinensis, Chinese wildrye	1949	1950	E	E
E. cinereus, Great Basin wildrye	1945	1946	G	E
E. glaucus, blue wildrye	1945	1946	[2] O	[2] O
E. junceus, Russian wildrye	1945	1946	E	E
E. sabulosus, Russian dune wildrye	1945	1946	G	O

See footnotes at end of table.

TABLE 2.—*Success ratings* [1] *in 1953 of 121 species, varieties, and strains seeded in preliminary row tests at Manitou Experimental Forest, 1945–50*—Continued

Scientific and common name	Date planted		Rating [1] of seeded stands planted	
	In fall	In spring	In fall	In spring
Elymus triticoides, beardless wildrye	1945	1946	[2] O	[2] O
Eragrostis curvula, weeping lovegrass	1949	1950	[2] O	[2] O
E. trichodes, sand lovegrass	1946	1947	[2] O	[2] O
Festuca arizonica, Arizona fescue	1945	1946	G	G
	1946	1947	E	E
F. arundinacea, reed fescue	1945	1946	[2] O	[2] O
F. elatior, meadow fescue	1945	1946	[2] O	[2] O
F. idahoensis, Idaho fescue	1949	1950	P	G
F. ovina, sheep fescue	1946	1947	E	E
F. ovina var. *duriuscula*, hard fescue	1949	1950	F	G
F. ovina var. *sulcata*, grooved sheep fescue	1949	1950	F	G
F. rubra, red fescue	1945	1946	P	F
F. rubra var. *commutata*, Chewings fescue	1948	1949	[2] O	[2] O
F. thurberi, Thurber fescue	1945	1946	O	O
	1946	1947	G	G
Glycyrrhiza lepidota, American licorice	1946	1947	O	O
Hedysarum boreale, northern sweetvetch	1949	1950	O	O
Hilaria jamesii, galleta	1948	1949	O	O
Hordeum brevisubulatum, short-awned barley	1945	1946	E	E
H. bulbosum, bulbous barley	1945	1946	[2] O	[2] O
Juniperus communis, common juniper	1948	1949	O	O
Kochia scoparius, belvedere summercypress	1948	1949	[2] O	[2] O
Koeleria cristata, prairie junegrass	1946	1947	O	G
Lolium perenne, perennial ryegrass	1946	1947	O	E
L. remotum, hardy ryegrass	1946	1947	[2] O	[2] O
Lotus corniculatus, birdsfoot trefoil	1945	1946	[2] O	[2] O
Lycurus phleoides, wolftail	1945	1946	[2] O	[2] O
Medicago falcata, sickle alfalfa	1949	1950	[4] O	E
M. sativa, alfalfa (hort. var. SEVELRA)	1948	1949	E	E
M. sativa var. *glutinosa*	1949	1950	F	F
Muhlenbergia montana, mountain muhly	1945	1946	O	E
M. wrightii, spike muhly	1945	1946	G	E
Onobrychis viciaefolia, common sainfoin	1948	1949	O	G
Oryzopsis hymenoides, Indian ricegrass	1945	1946	G	E
Penstemon palmeri, Palmer penstemon	1949	1950	O	F
Phalaris arundinacea, reed canarygrass	1945	1946	P	F
Phleum phleoides, dryland timothy	1948	1949	E	P
P. pratense, timothy	1945	1946	[2] O	[2] O
Poa ampla, big bluegrass	1945	1946	E	E
P. ampla, big bluegrass (hort. var. SHERMAN)	1948	1949	E	G
P. canbyi, Canby bluegrass	1946	1947	O	O

See footnotes at end of table.

TABLE 2.—*Success ratings* [1] *in 1953 of 121 species, varieties, and strains seeded in preliminary row tests at Manitou Experimental Forest, 1945–50*—Continued

Scientific and common name	Date planted		Rating [1] of seeded stands planted	
	In fall	In spring	In fall	In spring
Poa compressa, Canada bluegrass	1945	1946	G	G
P. pratensis, Kentucky bluegrass	1945	1946	F	G
P. trivialis, rough bluegrass	1948	1949	O	O
Populus tremuloides, quaking aspen	1948	1949	O	O
Prunus virginiana, common chokecherry	1948	1949	O	O
Purshia tridentata, antelope bitterbrush	1946	1947	O	O
Rhus trilobata, skunkbush sumac	1948	1949	O	O
Robinia neomexicana, New-Mexican locust	1949	1950	O	O
Sanguisorba minor, small burnet	1948	1949	[2] O	[2] O
Secale montanum, mountain rye	1946	1947	O	O
Sitanion hystrix, bottlebrush squirreltail	1946	1947	E	E
Sorghastrum nutans, yellow Indiangrass	1945	1946	[2] O	[2] O
Sporobolus cryptandrus, sand dropseed	1945	1946	[2] O	[2] O
Stipa viridula, green needlegrass	1945	1946	E	E
Trifolium ambiguum, kura clover	1948	1949	[4] O	E
T. fendleri, Fendler clover	1948	1949	[4] O	[4] O
T. fragiferum, strawberry clover	1946	1947	[4] O	[4] O
T. incarnatum, crimson clover	1948	1949	[2] O	[2] O
T. repens, white clover	1945	1946	[4] O	[4] O
Vicia tenuifolia, bramble vetch	1948	1949	O	O
V. villosa, hairy vetch	1948	1949	O	O
Vigna sinensis, common cowpea	1948	1949	O	O

[1] Ratings of seeded stands in this and other studies are based on the optimum stand of reseeded plants under existing site conditions. Ratings are as follows: O—Failure, VP—Very poor, P—Poor, F—Fair, G—Good, E—Excellent.

[2] Species established well but died out later, usually from drought and winterkill. Some were annuals only.

[3] Where four seeding dates are shown, the species were seeded in 2 or more years.

[4] Damaged or destroyed by pocket gophers.

A majority of the species made a good showing in the row plots, since weeding removed competing plants. Some species had good stands throughout the tests; some were good initially and then failed; and some were initially poor but thickened and became good. By 1953, 58 species, varieties, or strains with stands at least 4 years old were rated as being good or excellent. An additional 28 species had produced good or excellent initial stands but were either annuals that did not reestablish, or perennials that were killed by drought or cold. Five legumes were destroyed or badly damaged by rodents. The remaining 31 species produced poor initial stands or failed completely. Grasses averaged better as a group than did broad-leaved herbs and shrubs.

319369—55——3

When all factors were considered, species that showed the most promise up to 1953 in the row trials were: Crested,[5] Fairway crested, intermediate, Siberian, bluebunch, and slender wheatgrasses; Russian wildrye; smooth and meadow bromes; Arizona and sheep fescues; big bluegrass; alfalfa; Siberian peashrub; and oldman wormwood.

Range Tests

Thirty-five grasses and clovers were seeded in tests under range conditions. The species, areas, thoroughness of seedbed preparation, planting dates, and the 1953 results are shown in tables 3 and 4. Several species, tested only in one to three areas, either failed completely or produced poor stands and are not included in the tables. These are mountain brome, mountain rye, blue wildrye, blue grama, Indian ricegrass, reed canarygrass, yellow sweetclover, white clover, and bulbous, Kentucky, and Canada bluegrasses.

Applicable to the abandoned, eroded farmland that is a major seeding problem in the Front Range, seven range tests were made on typical abandoned lands at the Manitou Experimental Forest from 1946 to 1949. Some poor stands were obtained from four 1946 and 1947 seedings in Corral and West fields because of inadequate seedbed preparation (table 4). Better results were obtained from seeding on good seedbeds in 1948 at West field, and in 1946 to 1949 at Headquarters and Sinclair fields (table 3). Intermediate and crested wheatgrasses, Russian wildrye, and smooth brome, on the average, produced the best stands.

Two studies on steep, south-facing, eroding slopes at Missouri Gulch, Manitou Experimental Forest, were complete failures, and the results are not shown in tables 3 and 4. Although good germination was obtained from hand seeding of all species in both the spring and fall of 1949, the seedlings did not become established. Species tried in these tests were crested, rhizomatous crested, tall, beardless, intermediate, stiffleaf, slender, and pubescent wheatgrasses; meadow and smooth bromes; Canada, blue, and Russian wildryes; Arizona, sheep, and red fescues; Indian ricegrass; big bluegrass; mountain rye; and oldman wormwood. This area is typical of steep south exposures on the Front Range, where more information is needed regarding species and methods of seeding.

A steep, eroding slope at the Abbot Tract, 25 miles southwest of Colorado Springs, was terraced for erosion control. Machinery disturbed the entire area and practically all native vegetation was killed so that competition was lacking and moisture conditions were improved. In spite of this, only pubescent wheatgrass, Russian wildrye, and smooth brome gave good or excellent stands.

Many depleted range areas in need of seeding are open parks with dry, compact, and sometimes rocky soils and low-growing and low-value vegetation. Seedings at the following locations are typical of

[5] What has been called standard crested wheatgrass is now regarded by most authorities as desert wheatgrass (*Agropyron desertorum*) and Fairway crested wheatgrass as the true crested wheatgrass (*A. cristatum*). As used here, the common name crested wheatgrass will refer to what has been known as Standard and the Fairway form will be called Fairway. A form with short, slender rhizomes will be called rhizomatous crested wheatgrass.

such site conditions: Turner Gulch, Paige Ranch, Richaborger, Glentivar, Three-Mile Creek, and Eagle Rock, all either in or near South Park, and Prairie Divide, 40 miles northwest of Fort Collins, Colo. Natural recovery of good native vegetation through management would be slow on such areas, as evidenced by an enclosure near Turner Gulch and Eagle Rock, which has been protected from grazing since 1938. The area inside the enclosure shows little improvement. Seedbed preparation was difficult in the firm soil. A tractor that normally plowed 2 furrows 4 to 6 inches deep in second gear could hardly plow 2 furrows 2 to 3 inches deep in low gear, and even then the plow sometimes came out of the hard ground. At Turner Gulch and Paige Ranch the disk killed only about one-fourth of the native vegetation in 1946, and poor seeded stands resulted. A moldboard plow was used on the next three areas in 1948 and 1949, producing a better seedbed and better stands. The area at Glentivar before and after seeding is shown in figure 8. Eagle Rock was the site of a test of seven methods of seedbed preparation in the spring of 1951. Where native vegetation was killed, a good seeded stand developed. The results of species adaptability varied with the locations, but in general, on the first six areas, intermediate, crested, and beardless wheatgrasses, smooth brome, and Russian wildrye produced the best stands on the average in 1953.

Prairie Divide had more moisture than the six other areas in open parks. A good seedbed was prepared and most of the species grew vigorously. Excellent stands were produced by intermediate, crested, pubescent, and slender wheatgrasses; Russian wildrye; smooth brome; and sheep fescue.

The two trials west of Monument were typical of rough, weedy openings with good soil at lower elevations in the ponderosa pine type. A high percentage of the species grew well. Those that produced the best stands were intermediate, crested, pubescent, and beardless wheatgrasses; Russian wildrye; smooth brome; big bluegrass; and sand lovegrass.

The two trials at Turkey Creek, southwest of Colorado Springs, were typical of weedy openings, with poor soil at lower elevations in the ponderosa pine type. A good seedbed was prepared, but because of the poor soil and dry summers of 1950–53, the only species producing good stands were intermediate and pubescent wheatgrasses and Russian wildrye.

Sanborn Park, Norwood, and 25-Mesa represent the open, sagebrush-covered, low-forage-producing parks often found in the ponderosa pine zone in southwestern Colorado, and Dolores represents the weedy openings. Crested wheatgrass at 25-Mesa produced a good stand from the 1946 seedings, when a fair seedbed was obtained (fig. 9). Better seedbeds were obtained in 1949 and 1950, but the dry summers that followed caused poor stands of most species. Only crested and intermediate wheatgrasses and Russian wildrye produced good stands. At Sanborn Park, with good seedbed preparation, intermediate and crested wheatgrasses, Russian wildrye, smooth brome, and big bluegrass developed good stands. At Norwood where only part of the native vegetation was killed, only crested wheatgrass produced a good stand, and intermediate wheatgrass made a fair stand.

TABLE 3.—*Success ratings* [1] *in 1953 of 23 species seeded with good seedbed preparation in 15 range tests at 12 locations*

Species [2]	Headquarters and Sinclair fields (Manitou), seeded April 1946, 1948, and 1949 [3] [4]	West field (Manitou), seeded October 1948	Richaborger, seeded October 1948	Three-Mile Creek, seeded October 1948	Sanborn Park, seeded October 1948	Monument, seeded April and October 1949 [4]	Turkey Creek, seeded April and October 1949 [4]	Glentivar, seeded October 1949	Prairie Divide, seeded October 1949	25-Mesa, seeded September 1949 and May 1950	Abbot Tract, seeded April 1950	Eagle Rock, seeded April 1951
Russian wildrye	E	E			E	E	G	E	E	G	G	E
Intermediate wheatgrass	E	E	F	G	E	E	G	E	E	G		E
Crested wheatgrass	E	G	G	G	E	E	P	E	E	G	F	E
Smooth brome	E	G	G	G	G	E	F	G	E	F	G	E
Beardless wheatgrass		P	F	G		G	P	E				G
Bluebunch wheatgrass									F			
Pubescent wheatgrass	P	F	VP	F		E	G	G	E		E	F
Big bluegrass		P	G	F	G	G	VP	F	F	P	F	P
Slender wheatgrass		VP	G	G	VP				E	F		P
Sheep fescue						F	VP	F	E			
Arizona fescue		P	F	F				VP				VP
Thickspike wheatgrass						P	F					
Rhizomatous crested wheatgrass		G	VP	P					P			
Meadow brome		P	P	P		VP						
Tall wheatgrass		VP	O	VP	F	P	F	VP	VP		VP	
Sand lovegrass						G	P					
Stiffleaf wheatgrass		VP	VP	VP					P			
Orchardgrass		VP	O	O	F			VP			VP	
Red fescue		VP	G	VP	VP			VP				
Timothy										VP		

Western wheatgrass							VP	VP				O	
Tall oatgrass		O	O	O	P								
Meadow fescue		O	O	O	VP				O		VP		

[1] Ratings of seeded stands in this and other studies are based on the optimum stand of reseeded plants under existing site conditions. Ratings are as follows: O—Failure, VP—Very poor, P—Poor, F—Fair, G—Good, E—Excellent.

[2] Species are listed in approximate order of overall success.

[3] Grazing studies, different species seeded in years shown.

[4] Average of two areas.

TABLE 4.—*Success ratings [1] in 1953 of 16 species, seeded with fair or poor seedbed preparation, in 9 range tests at 7 locations, 1946–50*

Species [2]	Fair seedbed preparation			Poor seedbed preparation			
	25–Mesa, seeded August 1946	Corral and West fields, seeded April 1947 [3]	Corral and West fields, seeded October 1946 [3]	Turner Gulch, seeded October 1946	Paige Ranch, seeded October 1946	Dolores, seeded August 1950	Norwood, seeded September 1950
Intermediate wheatgrass		G	E	F	P	F	F
Crested wheatgrass	G	G	F	P	VP		G
Russian wildrye		F				P	P
Smooth brome	F	G	G	VP	VP	P	P
Meadow brome		G	F	P	VP		
Western wheatgrass	P	F	VP	VP	VP		
Tall wheatgrass		P				VP	VP
Sheep fescue						VP	P
Beardless wheatgrass						VP	VP
Thickspike wheatgrass						VP	VP
Big bluegrass							VP
Orchardgrass	VP	O				VP	P
Timothy	P		O	O	O		VP
Slender wheatgrass	O		VP	O	O		
Tall oatgrass							VP
Meadow fescue	O		O	O	O		VP

[1] Ratings of seeded stands in this and other studies are based on the optimum stand of reseeded plants under existing site conditions. Ratings are as follows: O—Failure, VP—Very poor, P—Poor, F—Fair G—Good, E—Excellent.

[2] Species are listed in approximate order of overall success.

[3] Average of two areas.

F-476601, 476599

FIGURE 8.—Glentivar before and after seeding: *A*, Fourteen grasses were seeded on each of two plowed areas in October 1949; *B*, excellent stand of intermediate wheatgrass in July 1954. In 1953 this plot produced 783 pounds of grass per acre as compared to 34 pounds of palatable native grass on the unplowed and unseeded area.

F-448267.448268

FIGURE 9.—*A*, Before seeding in the fall of 1946, 25-Mesa supported a dense stand of sagebrush; *B*, good stand of crested wheatgrass on a portion of the area in 1949. Palatable grass increased from 100 pounds per acre in 1946 to 698 pounds per acre in 1949 as the result of reseeding.

The compact soil at Dolores made it impossible to kill more than a small part of the native vegetation with the light disk that was available. The competition from the native grasses and weeds caused poor stands of most seeded species, but intermediate wheatgrass produced a fair stand.

Herbage Yields

When seeded to adapted grasses, areas in the ponderosa pine zone will quickly outproduce the depleted ranges many fold (table 5). Even though 1953 was a generally dry season and yields were relatively low, at Monument, for example, crested wheatgrass produced 1,697 pounds per acre, intermediate wheatgrass 1,841 pounds per acre, and Russian wildrye 827 pounds per acre. In contrast, the adjacent native range produced 469 pounds of palatable grass and forb herbage per acre. Other range tests showed comparable results.

Herbage yields at the Manitou Experimental Forest of 5- to 8-year-old stands of crested and intermediate wheatgrasses, smooth brome, Russian wildrye, and a mixture show that production can be maintained over a period of years (table 6). Herbage yields on these grazed ranges fluctuated because the precipitation varied. However, yields in 1953 were nearly double those of comparable, native grassland ranges nearby that had been well managed for 11 years.

It should be noted that high yields and high stand ratings are not always closely correlated. For example, a low-growing and low-yielding species, such as blue grama, may have a full stand and rate excellent; whereas scattered plants of tall-growing intermediate wheatgrass may produce more herbage, yet rate only fair as to stand.

Observed Seedings

The 391 seedings by other agencies and individuals that were observed in this study were scattered over a wide area. A total of 20 species were used in these seedings (table 7). Seedings varied in size from small range tests to tests on areas of several hundred acres. Locations of seedings are shown on the map (fig. 4) by dots. Where seedings occurred close together, several are grouped into one dot with a number showing how many seedings occurred at that location. For example, one dot represents 48 seedings in Teller County.

Of all the observed seedings, 74 percent produced fair to excellent stands and could, therefore, be considered successful. Thirteen percent were poor stands, and 13 percent were failures. Crested wheatgrass produced fair to excellent stands on 82 percent of the 265 seedings in which it was used. Smooth brome was successful in 74 percent of 195 seedings. Yellow sweetclover stands averaged 67 percent fair or better, mainly because most of the seedings were on good sites where the sweetclover was able to reseed itself. Alfalfa seedings were also generally made on better than average sites, and of 34 seedings, 85 percent averaged fair or better. Intermediate wheatgrass stands rated fair or better in all 13 cases where this grass was used.

Good stands of these seedings were usually associated with good seeding practices. For example, all intermediate wheatgrass plantings had fair to good seedbed preparation and all were successful. The 47 poor stands or failures from the 265 crested wheatgrass plantings were mainly the result of poor seeding methods.

Selection of Species

Experimental and other range seedings, considered as a group, were a good test of species adaptability in this area. Two species that were widely seeded and generally well adapted were crested wheat-

TABLE 5.—*Yields of 4- and 5-year-old stands of 19 reseeded grasses and adjacent native range at 8 locations, Colorado, 1953*

[Air-dry yield per acre]

Species [1]	Prairie Divide, seeded October 1949	Monument, seeded April and October 1949	West field, seeded October 1948	Glentivar, seeded October 1949	Three-Mile Creek, seeded October 1948	25-Mesa, seeded September 1949 and May 1950	Turkey Creek, seeded April and October 1949	Richaborger, seeded October 1949
Reseeded species:	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Intermediate wheatgrass	3, 216	1, 841	771	783	346	707	167	88
Crested wheatgrass	2, 286	1, 697	1, 004	495	566	803	60	218
Russian wildrye	1, 432	827	395	555		397	198	
Pubescent wheatgrass	1, 782	1, 861	580	393	38		150	8
Beardless wheatgrass		1, 091	249	503	598		32	175
Bluebunch wheatgrass	930							
Smooth brome	2, 016	612	441	445	280	318	92	45
Big bluegrass	878	798	159	329	411	147	0	262
Sheep fescue	1, 874	737		162			0	
Arizona fescue			236	23	334			168
Slender wheatgrass	1, 110		179		161	[2]		199
Rhizomatous crested wheatgrass	221		437		134			21
Tall wheatgrass	334	576	44	25	0		175	0
Meadow brome		137	287		113			14
Indian ricegrass		782					19	
Sand lovegrass		490					80	
Thickspike wheatgrass		208					73	
Blue grama		406					0	
Western wheatgrass		133					0	
Native unseeded range:								
Palatable grasses and forbs	[2]	469	[2]	34	51	[2]	58	[2]

[1] Species are listed in approximate order of yield.
[2] Herbage yields not obtained.

TABLE 6.—*Average annual yield of air-dry herbage per acre at Manitou Experimental Forest, 1947–53*

Year	Crested wheatgrass [1]	Smooth brome [1]	Mixture [2]	Intermediate wheatgrass [3]	Russian wildrye [4]
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1947	1,739	1,298	2,968	----------	----------
1948	2,938	2,320	3,315	----------	----------
1949	2,091	1,308	2,585	1,566	----------
1950	1,070	669	1,018	1,769	409
1951	593	441	554	710	506
1952	1,195	749	1,223	1,054	753
1953	1,399	1,120	1,546	1,252	1,684

[1] Seeded in 1946.
[2] Crested wheatgrass, smooth brome, and yellow sweetclover seeded in 1946.
[3] Seeded in 1948.
[4] Seeded in 1949.

TABLE 7.—*Success of 20 species in 391 observed range seedings in the ponderosa pine zone* [1]

Species	Times seeded	Seedings by class				
		Excellent	Good	Fair	Poor	Failure
	No.	*No.*	*No.*	*No.*	*No.*	*No.*
Crested wheatgrass	265	64	127	27	21	26
Smooth brome	195	31	88	25	24	27
Yellow sweetclover	153	17	60	26	30	20
Alfalfa	34	4	25	------	1	4
Timothy	16	------	8	2	4	2
Intermediate wheatgrass	13	7	5	1	------	------
Orchardgrass	9	------	3	1	3	2
Western wheatgrass	8	1	------	3	4	------
Kentucky bluegrass	7	------	------	1	3	3
Slender wheatgrass	6	------	1	------	5	------
Alsike clover	5	1	1	1	------	2
Quackgrass	4	3	1	------	------	------
Big bluegrass	4	2	1	------	------	1
Tall oatgrass	4	------	2	------	1	1
Redtop	3	------	3	------	------	------
Bulbous bluegrass	3	------	------	1	1	1
Russian wildrye	2	1	------	1	------	------
Blue grama	2	------	------	------	1	1
White clover	2	------	------	1	------	1
Perennial ryegrass	2	------	------	------	------	2

[1] All locations, methods, and seasons of seeding have been averaged.

grass and Russian wildrye. Although Russian wildrye was not seeded as widely as crested wheatgrass, it did well in all seeding tests. Practically the only failures for these species occurred where competing vegetation had not been removed. The upper elevational limit of crested wheatgrass has not been established. It is recommended that seedings of this species be made only on an experimental basis at elevations in excess of 9,500 feet. Intermediate wheatgrass established easily and grew well on all except two low-rainfall areas that were also exposed to drying winds, where much of the stand died during the cold winters of 1951–52 and 1952–53. Smooth brome generally produced good stands, but it was not adapted to the drier sites.

The performance of the following species has been good enough to warrant their consideration for selected areas. Beardless and bluebunch wheatgrass plants were large and vigorous, but stands varied from poor to excellent. Except on dry sites at low elevations, Arizona and sheep fescues and big bluegrass plants grew vigorously, but good stands were difficult to establish. Western, thickspike, rhizomatous crested, and stiffleaf wheatgrasses, Indian ricegrass, and blue grama produced good plants but only poor to fair stands. Bulbous bluegrass was seeded only at Sanborn Park, but it produced a good stand of small plants.

The following species proved to be susceptible to winterkilling, but may be used under certain conditions. Pubescent wheatgrass and meadow brome grew well but slight to heavy winterkilling occurred on most dry locations. Tall wheatgrass grew vigorously on many sites, but killing ranged from slight to complete on all exposed sites during dry winters. Tall oatgrass, orchardgrass, and red and meadow fescues produced good stands on good sites, but from 75 to 100 percent of the plants on most Front Range areas died during the dry winters of 1951–52 and 1952–53. Sand lovegrass produced poor to good stands of vigorous plants in three tests at low elevations, but plants winterkilled at the Manitou Experimental Forest.

Another group of plants were either short lived, adapted only to specific sites, or limited in usefulness. Some of them may be of value under restricted conditions. Slender wheatgrass, mountain brome, blue wildrye, and yellow sweetclover established well but were short lived and gradually thinned out, often disappearing from the stand. Alfalfa did well on good sites but was usually damaged severely by rodents. Canada and Kentucky bluegrasses, timothy, reed canarygrass, redtop, and alsike and white clover appeared to be adapted to moist sites only. Mountain rye and oldman wormwood were tried only once in range tests, and the results were poor.

Some main characteristics of the most promising species are summarized in table 8. The growth forms of some of these adapted species growing in row plots are shown in figure 10.

Mixtures or Single Species

Mixtures of grasses having different growth habits can provide a more varied forage than a single species. Also, the site adaptation of a mixture can be made rather broad by including species adapted to

TABLE 8.—*Adaptation, growth, and forage qualities of some of the species used for seeding in the ponderosa pine zone of Colorado*

Species [1]	Adaptation	Character of growth	Grazing value
Crested wheatgrass	Imported from the cold, dry plains of Siberia. Most widely used grass in range seedings. Does well on moderate to dry sites. Drought- and cold-resistant.	An easily established, vigorous-growing bunchgrass. Extensive root system. Grows early in the spring. Produces an abundance of viable seed. Not a vigorous spreader.	Furnishes excellent early spring grazing. Produces good gains on livestock. Withstands heavy grazing. Often cut for hay.
Russian wildrye	Introduced from Asia. Has grown well at all elevations and on both moist and dry sites. Drought-, cold-, and alkali-resistant.	A low-growing, long-lived bunchgrass, producing dense leafage but few flower stalks. Poor seed producer. Makes very early spring growth.	Excellent grazing throughout the year. Ready for grazing from 1 to 2 weeks earlier than crested wheatgrass; outstanding ability for regrowth.
Intermediate wheatgrass	Imported from Eurasia. Does well at all elevations on either dry or moist sites. Slight winterkill on dry exposed locations.	Tall, vigorous growth from rapidly spreading rootstocks. Easily established. Makes early spring growth and remains green until late summer. Good seed producer.	Excellent early spring and summer grazing for all classes of livestock; high carrying capacity and good livestock gains. Often cut for hay.
Smooth brome	Introduced from Europe. Well adapted to moist sites and good soils throughout the zone. Poor production on dry sites. Endures cold and drought.	Vigorous, sod-forming grass. May lose vigor for lack of nitrogen. Establishes slowly. Produces high yields on good sites. Grows early in the spring.	One of the most palatable grasses. Excellent for grazing. Does well when planted with a legume.
Pubescent wheatgrass	Imported from Eurasia. Adaptation similar to intermediate wheatgrass, but more winterkill at higher elevations.	Same as intermediate wheatgrass, but somewhat slower and more difficult to establish.	Similar to intermediate wheatgrass, but under some conditions it is less palatable.
Beardless wheatgrass	Native to western United States. Grows well at all elevations. Cold- and drought-resistant.	A vigorous bunchgrass with dense foliage. Slower to establish than crested or intermediate wheatgrass.	A very palatable, high-yielding grass. Excellent late spring and summer forage.
Meadow brome	Introduced from Europe. Does best on moist sites. Some winterkill on dry, exposed sites.	A bunchgrass, shorter in stature than smooth brome, but similar in many respects. Easily established and rapid growth on better sites.	Believed to be about the same as smooth brome.

See footnotes at end of table.

TABLE 8.—*Adaptation, growth, and forage qualities of some of the species used for seeding in the ponderosa pine zone of Colorado*—Continued

Species [1]	Adaptation	Character of growth	Grazing value
Arizona fescue	Native to ponderosa pine zone. Grows on wide variety of sites at midelevations.	Moderately tall, vigorous bunchgrass, with narrow, erect leaves. Difficult and slow to establish.	Excellent for spring and early summer. Loses its palatability in midsummer when plant matures.
Big bluegrass	Native to United States. Requires moderate moisture, but will grow at all elevations. Fairly drought- and cold-resistant.	A long-leafed bunchgrass. Slow to establish, but a good producer where adapted. Grows very early in the spring and again in the late fall.	Excellent for late fall grazing. Plants easily pulled up by grazing animals when the soil is moist.
Sheep fescue	Native to United States but some forms introduced. Best adapted to good sites at medium to high elevations, but also drought-resistant.	Low-growing, fine-bladed bunchgrass. Slow to establish. Abundant, fine basal leaves and a dense root system. Good for soil cover.	Fair palatability, especially in the spring.
Tall wheatgrass	Imported from Asia Minor. Does best on good sites at both high and low elevations. Alkali-resistant. Extensive winterkill on dry exposed sites.	A robust, tall-growing, high-yielding bunchgrass. Easily and rapidly established. Grows early and remains green in late summer. Develops coarse seedstalks. Good seed producer.	Very palatable, nutritious forage; good for grazing use in the spring and summer.
Slender wheatgrass	Native to western United States. Best adapted to medium and high elevations. Needs moderate or better moisture. Some winterkill.	A short-lived perennial bunchgrass, easily invaded by other plants. Makes rapid and vigorous growth for a few years. Easy to establish.	Fair palatability during summer period.
Western wheatgrass	Native to United States; best adapted to fine-textured and moist soils at low and intermediate elevations. Drought-, cold-, and alkali-resistant.	Forms an open sod from vigorous underground rootstocks. Difficult and slow to establish. Low seedling vigor but vigorous when once established.	Palatable when young. Cures well on stem and is good winter grazing.

Thickspike wheatgrass	Native to United States. Prefers moist, well-drained soils. Does best at lower elevations. Drought-resistant.	A sod-forming grass, spreading from underground rootstocks. Slow and difficult to establish. Vigorous when once established.	Excellent grazing; probably best when planted in mixtures of other grasses.
Orchardgrass	Introduced from Europe. Only adapted to good sites at medium to high elevations. Very shade tolerant. Extensive winterkill on dry, exposed sites.	A vigorous, high-producing, long-lived perennial bunchgrass; easy to establish; grows rapidly. Grows early in the spring and late in the fall.	Young forage palatable to all classes of livestock.
Yellow sweetclover	Introduced from Europe; grows well at all elevations but requires moderate to high moisture.	A rank biennial legume, which in this region does not perpetuate itself well, especially when grazed. Easy to establish; rapid and abundant growth. Adds nitrogen to the soil.	Palatable, but may cause bloat if grazed alone. Increases grass yields, when planted in mixtures.

[1] Species are listed in approximate order of adaptation for seeding ponderosa pine areas.

F-465961-6

FIGURE 10.—Crested, beardless, bluebunch, and intermediate wheatgrasses; Russian wildrye; meadow and smooth bromes growing in row plots at the Manitou Experimental Forest, Colo.

various soil and moisture conditions. This may be desirable on mountain lands where sites change markedly in short distances. On the other hand, mixtures have certain disadvantages. They are often hard to seed evenly, especially through a drill. Because of differences in palatability, proper grazing use of the different species is difficult to achieve. Many mixtures of two species have been converted to pure stands because one species was not as tolerant of grazing as the other.

Experience in Colorado indicates that seedings of single grass species are usually more satisfactory than mixtures, especially on uniform areas. This simplifies the planting operation and later the grazing management. Species can be selected that will provide grazing when most needed. To extend the grazing season, early- and late-growing species can be seeded in separate allotments and grazed in rotation. Such a procedure is suggested in Idaho (*15*).

Where adapted, legumes should be seeded with grass. Legumes usually increase forage production and forage nutritive values. Their greatest benefit is an increase of soil fertility through the addition of soil nitrogen.

HOW TO SEED

The two main essentials for obtaining good stands of seeded grass on ponderosa pinelands are (1) Kill competing vegetation, and (2) use proper planting methods. Good seeding practices usually result in good stands, poor practices in poor stands (fig. 11).

F-465958

FIGURE 11.—Plowing and light disking kill the heavy stand of competing undesirable and unpalatable grass, mostly sleepygrass and weeds, and prepare a good seedbed on this abandoned farmland. This is followed by drilling. Good seedbed preparation is expensive, but it results in good stands of reseeded grass, which develop rapidly.

Removing Competition

Herbaceous vegetation is the most general type of competition in the ponderosa pine zone, although big sagebrush areas are common in southwestern Colorado. The experimental studies and the observed

range seedings generally show that it is necessary to kill the undesirable grasses, weeds, and brush and to prepare a good seedbed to get a good stand of seeded grass. The removal of plant competition is particularly important to conserve moisture for seeded species during the period of critical establishment. Well-prepared seedbeds permit more uniform depth of drilling and hold moisture near the seed better than do loose, trashy seedbeds.

In the 391 observed range seedings, the best stands generally grew in the best prepared seedbeds. Typical examples were South Park, where 100 acres, disked and drilled, gave a good stand of reseeded grass, whereas an adjacent area, drilled without seedbed preparation, was a failure. South of Norwood, a 40-acre sagebrush park that was railed and broadcast gave a poor stand of grass, but 350 acres that were plowed, broadcast, and cultipacked gave an excellent stand.

Seven methods of seedbed preparation were tested at Eagle Rock in April 1951: (1) Moldboard plow, (2) brushland plow, (3) heavy offset disk, (4) medium offset disk, (5) sweeps, (6) chisels, and (7) field cultivator. The soil was compact and supported dense, low-growing native vegetation. Average stand ratings of the two most successful species, crested wheatgrass and Russian wildrye, were as follows in 1953:

Method of seedbed preparation:	*Rating*	
Moldboard plow	(Excellent)	9. 2
Brushland plow	(Excellent)	9. 0
Heavy offset disk	(Excellent)	8. 6
Medium offset disk	(Good)	8. 0
Sweeps	(Good)	6. 8
Chisels	(Fair)	5. 8
Field cultivator	(Very poor)	2. 0

Forage yields in 1953 reflected the same general relationship to seedbed preparation as did the 1953 stand ratings shown above.

The moldboard plow was the most effective in eliminating native vegetation—removing approximately 95 percent. The stands and yields that developed were the best in this test. The heavy disk and the brushland plow removed most of the competition, and the stands and yields resulting from these treatments were only slightly less than those from the areas worked with the moldboard plow. The other implements eliminated proportionately smaller amounts of the vegetation, and forage stands and yields were correspondingly lower.

Additional tests involving disking and fall seeding were made in 1946 at four locations (Corral field, West field, Paige Ranch, and Turner Gulch) similar to Eagle Rock in soil and vegetation conditions. The light disk used at these locations killed less than one-fourth of the native vegetation. The resulting stands of seeded grasses ranged from very poor to fair—the best stands occurring on plots with the least native vegetation remaining.

On land that has recently been in grain crops, grass can be drilled into the stubble without further seedbed preparation. Because competing vegetation was killed by cultivating for the grain crop, excellent stands of seeded grasses have developed from this practice.

Big sagebrush lands present a special problem in seedbed preparation but have particularly good possibilities for seeding. Such lands, typified by 25-Mesa (fig. 9, *A*), are common in parks and valleys in

the ponderosa pine zone in southwestern Colorado, although they make up a relatively minor portion of the total range in this zone. Productive stands of seeded grasses were obtained at 25-Mesa following sagebrush removal and seeding by various methods (fig. 9, *B*).

Some guides, based on studies in western Colorado (*1*, *5*, *7*), for sagebrush removal and the seeding of sagebrush lands in the ponderosa pine zone are as follows:

1. Sagebrush needed for browse of livestock or game should not be killed.
2. Sagebrush should be eradicated only in the summer or early fall, before the seed is ripe. Late fall operations may plant another crop of sagebrush.
3. Burning is an effective and inexpensive method of killing the brush and preparing the land for drilling where there is little understory vegetation. Fire should be used with caution, especially on watersheds and near timber (*12*, *13*).
4. Disk-plowing is widely used—an effective method that can be employed on most lands if care is taken in the operation.
5. Railing is inexpensive and fairly effective on big sagebrush that is old and brittle but not successful on young, flexible plants.
6. Pipe harrows cover seed on rough, rocky lands and kill some small, brittle plants.
7. Spraying with 2,4–D offers promise as a cheap and fast method of killing big sagebrush, mostly to allow desirable native forage plants to increase (*6*). More research is needed in the use of chemicals and in the ecological changes that result from spraying.

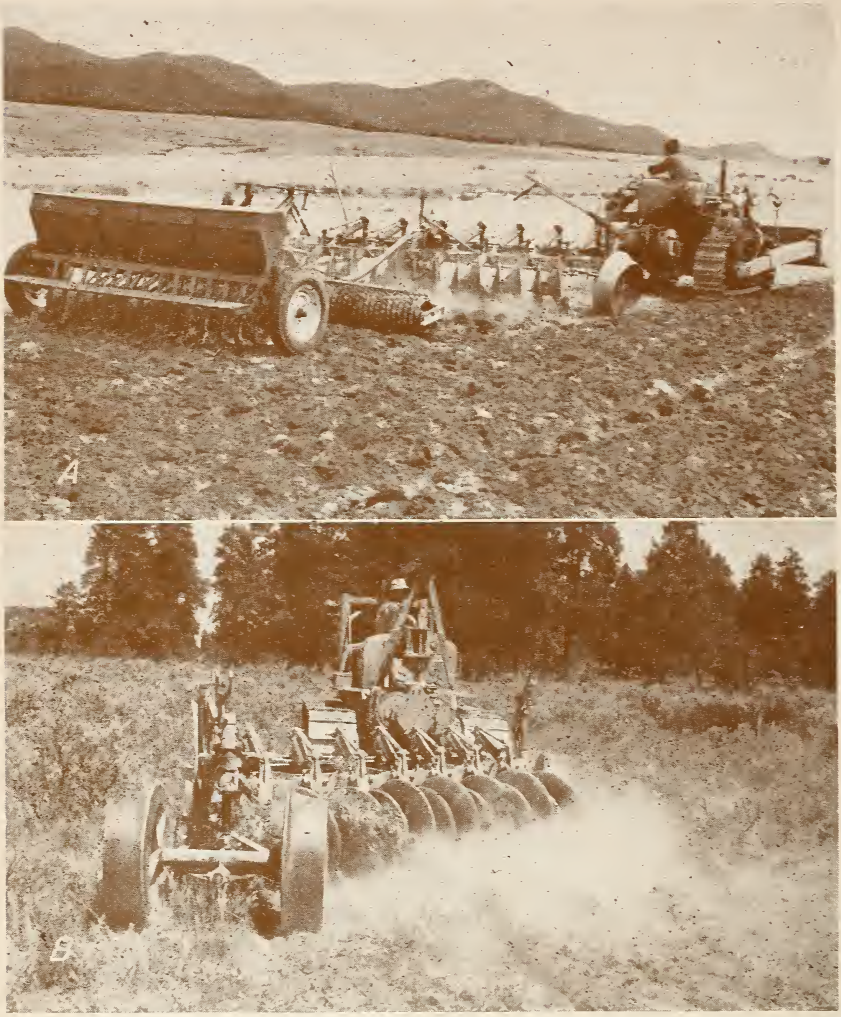
Equipment for Seedbed Preparation

Several methods of removing competition and preparing a seedbed are adapted to the vegetation, topography, and soil conditions encountered on ponderosa pine ranges. Some common machines useful for this purpose and adaptable to Colorado conditions are as follows:

Moldboard and disk plows are expensive to operate but have been widely used and do an excellent job of killing herbaceous vegetation on rock-free areas. Large disk plows are also excellent for killing heavy brush. In all plowing, a depth of 3 to 5 inches is usually desirable for disk plows and 4 to 6 inches for moldboard plows. These depths are sufficient to kill the plants and require a minimum of power. Plowing generally leaves a loose seedbed and care must be taken to avoid seeding too deeply. On areas subject to erosion, contour plowing is usually recommended. When plowing at a suitable time for seeding, the seed can be broadcast on freshly plowed ground, or planted by a drill pulled behind the plow (fig. 12, *A*).

Brushland plows were developed primarily for use on rough and rocky lands. They are sturdy plows which weigh 6,000 pounds and give a high brush- and weed-kill. Their outstanding feature is the seven pairs of unequal-sized disks mounted with a pitch on jump arms and controlled by springs, so that each pair can rise over rocks and brush independently of the other disks, thus reducing breakage and clogging (fig. 12, *B*).

Heavy offset disks do an excellent job of killing sagebrush and weeds on moderately rock-free areas. On loose or sandy soils they cut too



F-465817, 465969

FIGURE 12.—The brushland plow: *A*, This plow is killing the low-value vegetation, the cultipacker is firming the seedbed, and the seed is being drilled in one operation, at a cost of $2.50 per acre, exclusive of seed; *B*, this brushland plow is doing a good job of killing sagebrush in the ponderosa pine zone.

deeply and require heavy tractors for pulling. On compact soils and brush areas, heavy disks that weigh 3,000 to 6,000 pounds and have 26- to 30-inch disks are effective in killing the native vegetation and preparing a good seedbed.

Wheatland-type plows have been successful for killing brush and weeds on many relatively rock-free areas in the ponderosa pine zone where the soil is not too dry and compact, and the brush not too thick. Heavy-duty plows of this type weigh about 3,000 pounds.

Planting Methods

Ideally, all seed should be placed at a depth where moisture conditions are most favorable for germination and establishment—usually the maximum depth from which the seedlings will emerge. This can most nearly be accomplished by drilling. In broadcasting, fewer seed can be covered at the optimum depth, and heavier seeding rates are required for satisfactory results.

Drilling is the best large-scale method of distributing seed evenly and covering it uniformly. Most grasses for range planting are best sown directly from the grain box. Clover, alfalfa, and small-seeded grasses may be sown from the smaller seed box, often called a grass seeder. It is also possible to drill in alternate rows when seeding from both boxes, a procedure often recommended for seeding mixtures of species having different growth habits. Where seeds are of similar size and can be covered at the same depth, alternate drill rows may be seeded by partitioning the drill box. Where mixtures include species requiring different planting depths, one possibility is to drill twice with the second set of drill rows in between those drilled the first time. However, with ingenuity more economical procedures can be devised, such as dropping the smaller seed ahead of or behind the furrow opener, and using chain drags to assist in covering the seed adequately.

Depth of covering for most grass seeds should be less than 1 inch. Deeper planting reduces emergence. Aim at planting medium-sized seeds such as the wheatgrasses between ½ and 1 inch deep. Small-seeded grasses should be covered only ¼ to ½ inch deep. Plant shallow on heavy clay soils to reduce losses from soil crusting, but deeper on sandy soils to avoid losses from rapid soil drying.

Row spacing depends upon site conditions and the purpose of the seeding. Generally competition for moisture among seeded plants requires wider spacing. For best plant development, dry sites require wider spacings than moist sites. For grazing, close spacings from 6 to 10 inches are usually preferable. Such spacings produce smaller plants but keep down weeds and brush better and give more soil protection than do larger plants at wider spacings, and these smaller plants give comparable forage yields. Wider spacings of 12 to 18 inches are best for hay, because they produce tall plants. Widely spaced plants, at 24- to 48-inch row spacings, normally yield the most seed. These recommendations, based primarily on observations of the experimental and range seedings, are similar to those for Idaho and Utah (*4, 14*).

Broadcasting.—Where drilling is not feasible, broadcast the seed by machine or hand broadcasters and cover by light disking, or by pipe, spring, or spike-tooth harrows. Under most conditions, broadcast seeding without seed covering has not been successful. However, on rough, freshly worked areas, soil sloughing is often sufficient to cover the seed adequately. Broadcast seeding before or during leaf-fall in stands of aspen or oak has produced good stands in western Colorado. Falling leaves furnish the necessary covering for the seeds.

Recommended rate of seeding.—Plenty of seed helps to establish full stands quickly and keeps down the invasion of weeds and brush.

Although sufficient seed is a necessity, too much seed increases seeding costs and weak stands may develop because of excessive competition.

The following factors determine the correct amount to sow: (1) Type of seedbed and efficiency of planting method, (2) purity and germination of seed, (3) size of seed, (4) growth characteristics, and (5) productive capacity of the site.

Recommended seeding rates and average seed size, germination, and purity of some more important species are given in table 9 (*16*). In general, species having small seeds, a million or more per pound, can be seeded at 2 to 4 pounds per acre. Crested wheatgrass and similar species having approximately 175,000 seeds per pound can be seeded at 4 to 7 pounds per acre. Species having larger seeds can be seeded at 7 to 12 pounds per acre. At the Manitou Experimental Forest, areas seeded to crested wheatgrass or smooth brome at 5 to 7½ pounds per acre and intermediate wheatgrass at 4½ pounds per acre have given excellent stands on well-prepared seedbeds.

Where seed is broadcast, or the seedbed is poor so that uneven covering is expected, the rate of seeding should be increased 25 to 50 percent. Seeding rates should also be increased to compensate for poor quality of seed.

Good seed is needed to grow good stands of grass. In buying seed, do not fail to determine the purity and germination, and examine it for chaff, straw, light seed and awns, to make sure it will feed through a drill. Seed houses are required to show the germination and purity on the tag. If there is no record, or if the seed is old and the germination questionable, send a representative sample (about one-fourth of a pound) to the State seed laboratory for testing. The laboratory tests will show the percent of germination, purity, and poisonous weed seed content.

The normal seeding rates are based on average germination and purity of good seed. For most of the species used for reseeding, these should be approximately 85 percent germination and 90 percent purity

TABLE 9.—*Seed size, average germination, purity, and recommended rate of seeding of some of the more important species*

Species	Seed per pound [1]	Germination [1]	Purity [1]	Normal seeding rate per acre
	Number	*Percent*	*Percent*	*Pounds*
Bluegrass, big	882,000	49	81	6
Brome, smooth	136,000	85	92	8
Fescue, sheep	680,000	85	96	5
Sweetclover, yellow	260,000	90	98	6
Wheatgrass, beardless	150,000	[2]	[2]	7
Wheatgrass, crested	175,000	85	95	5
Wheatgrass, intermediate	88,000	91	89	6
Wheatgrass, pubescent	100,000	85	93	7
Wheatgrass, slender	159,000	85	95	7
Wheatgrass, tall	79,000	90	94	8
Wildrye, Russian	175,000	85	91	6

[1] For average good lots of seed; see pp. 743–752, 1948 U. S. Dept. Agr. Yearbook.
[2] No data.

(table 9). When the germination and purity are lower than normal, the amount of seed should be increased accordingly. For example, using seed with the above-mentioned average purity and germination would give 0.77 pound of live pure seed (85 germination $\times$ 90 purity) per pound of purchased seed. But 40 percent germination and 85 percent purity would give only 0.34 pound of live pure seed (lps) per pound purchased. To determine the increased seeding rate, multiply the normal lps by the seeding rate and divide by the lps of the seed that is low in germination and/or purity. If the normal seeding rate is 7 pounds per acre, the new seeding rate in the example above would be 16 pounds per acre ($0.77 \times 7 \div 0.34 = 16$).

HOW TO GRAZE RESEEDED AREAS

Proper grazing management of reseeded areas is a major problem. Studies at Manitou Experimental Forest and observations of many older seedings indicate that a newly seeded area should not be grazed until the stand is sufficiently well established to prevent plants from being pulled up or trampled by grazing animals. Early or heavy grazing may either destroy a new stand or reduce plants in vigor so that they are slower in developing to full production. Grazing can usually commence during the late summer or fall of the second or third growing season. All seedings at the Manitou Experimental Forest have been grazed during the third growing season with good results (fig. 13). Graze reseeded areas moderately to leave enough of the plant to maintain its vigor and protect the soil (*2*, *10*).

F-468429

FIGURE 13.—This 4-year-old stand of intermediate wheatgrass is producing over one-half ton of air-dry herbage per acre. It was drilled on a well-prepared seedbed in the spring of 1948. Grazing commenced during the third growing season.

SUMMARY

Reseeding can restore the grass and help to prevent erosion on a half-million acres of depleted parks and openings in the ponderosa pine zone in Colorado. The ponderosa pine type extends along the Front Range in Colorado and across the southwestern part of the State, occupying about 4 million acres.

Twenty-eight studies were made at 20 locations to determine the species and methods for seeding these lands. In addition, records were obtained from 391 other seedings on lands in the ponderosa pine zone. Based on all studies and observations, the following recommendations are made for seeding parks and openings in the ponderosa pine zone:

Species.—Crested wheatgrass was the best adapted species throughout the ponderosa pine zone. It did especially well on dry sites. Russian wildrye, although not so widely seeded, did well in all tests. Smooth brome is well adapted to above-average moisture conditions. Intermediate wheatgrass grew well on all except two exposed sites, where some of the plants died during two dry, cold winters. Other species that gave good results on most areas are beardless and pubescent wheatgrasses, meadow brome, Arizona and sheep fescues and big bluegrass.

Removal of brush and weedy competition.—Seeded plants establish best and develop most rapidly without competition from native plants. The better the kill of competing plants, the better will be the stand of reseeded grasses. Following the planting of grain crops that have controlled the native plants, grass can be drilled directly into the stubble.

Seeding methods.—Drill most grasses at a depth of ½ to 1 inch except for small-seeded species, which may be drilled at ¼ to ½ inch. Drill deeper on sandy soil, shallower on clay soils. Row spacings of 6 to 10 inches are best for forage production.

Broadcasting is wasteful of seed if provisions for proper covering are not made, and should be used only where mechanical or natural seed covering will follow.

Rate of seeding varies with seed size and quality, seeding methods, and productive capacity of the site. Four to 7 pounds per acre is sufficient for most species like crested wheatgrass. Species with larger seeds are normally seeded at 7 to 12 pounds per acre, and species with small seeds at 2 to 4 pounds per acre.

Season of seeding.—Although spring seedings often produce good stands, fall seedings are generally more dependable. Because of a longer planting season and more favorable weather conditions, fall is the most practical time for large-scale range seedings. Along the Front Range, fall seedings may be made from September to November. In southwestern Colorado, with good summer precipitation, fall seedings can be made early in August.

Grazing of reseeded areas.—Until the stand is sufficiently well established to prevent plants from being pulled up or trampled, grazing of reseeded areas should be delayed. Grazing may usually begin during the late summer or fall of the second or third growing season. Early or heavy grazing may either destroy a stand or reduce plants

in vigor, so that they are slower to develop to a full stand. After the plants are well established, animals may graze the reseeded area if enough of the plant is left to maintain plant vigor and protect the soil.

COMMON AND BOTANICAL NAMES OF NATIVE SPECIES MENTIONED

Common name	*Botanical name*
Grasses	
Bluestem, little	*Andropogon scoparius*
Cheatgrass	*Bromus tectorum*
Danthonia	*Danthonia* spp.
Fescue, Arizona	*Festuca arizonica*
Grama, blue	*Bouteloua gracilis*
Muhly, mountain	*Muhlenbergia montana*
Muhly, slimstem	*M. filiculmis*
Sleepygrass	*Stipa robusta*
Wheatgrass, western	*Agropyron smithii*
Forbs (Herbs)	
Fleabane, trailing	*Erigeron flagellaris*
Shrubs	
Sagebrush, big	*Artemisia tridentata*
Sagebrush, fringed	*A. frigida*
Trees	
Aspen, quaking	*Populus tremuloides*
Douglas-fir	*Pseudotsuga menziesii*
Juniper	*Juniperus osteosperma*, *J. scopulorum*, *J. monosperma*
Oak	*Quercus* spp.
Pine, lodgepole	*Pinus contorta*
Pine, pinyon	*P. edulis*
Pine, ponderosa	*P. ponderosa*

LITERATURE CITED

(1) Doran, Clyde W.
1951. Guide for reseeding summer rangelands on Colorado's western slope. U. S. Forest Serv. Rocky Mountain Forest and Range Expt. Sta. Paper 6, 18 pp., illus. [Processed.]

(2) Frischknecht, Neil C., Harris, Lorin E., and Woodward, Harry K.
1953. Cattle gains and vegetal changes as influenced by grazing treatments on crested wheatgrass. Jour. Range Mangt. 6(3): 151–158, illus.

(3) Hafenrichter, A. L., Mullen, Lowell A., and Brown, Robert L.
1949. Grasses and legumes for soil conservation in the Pacific Northwest. U. S. Dept. Agr. Misc. Pub. 678, 56 pp., illus.

(4) Hull, A. C., Jr.
1948. DEPTH, SEASON, AND ROW SPACING FOR PLANTING GRASSES ON SOUTHERN IDAHO RANGE LANDS. Jour. Amer. Soc. Agron. 40 (11): 960–969, illus.
(5) ——— and Doran, Clyde W.
1950. PRELIMINARY GUIDE TO RESEEDING PINYON-JUNIPER LANDS OF WESTERN COLORADO. U. S. Forest Serv. Rocky Mountain Forest and Range Expt. Sta. Paper 4, 16 pp., illus. [Processed.]
(6) ——— Kissinger, N. A., Jr., and Vaughn, W. T.
1952. CHEMICAL CONTROL OF BIG SAGEBRUSH IN WYOMING. Jour. Range Mangt. 5(6): 398–402, illus.
(7) ——— Doran, Clyde W., Wasser, C. H., and Hervey, D. F.
1952. RESEEDING SAGEBRUSH LANDS OF WESTERN COLORADO. Colo. A. and M. Col. Bul. 413–A, 27 pp., illus.
(8) Johnson, W. M.
1945. NATURAL REVEGETATION OF ABANDONED CROP LAND IN THE PONDEROSA PINE ZONE OF THE PIKE'S PEAK REGION IN COLORADO. Ecology 26 (4): 363–374, illus.
(9) ———
1951. WHICH GRASS IS BEST? Amer. Cattle Prod. 32 (11): 11–13, illus.
(10) ———
1952. MANAGEMENT OF RESEEDED PASTURES. U. S. Forest Serv. Rocky Mountain Forest and Range Expt. Sta., 5 pp. [Processed.]
(11) ———
1953. EFFECT OF GRAZING INTENSITY UPON VEGETATION AND CATTLE GAINS ON PONDEROSA PINE-BUNCHGRASS RANGES OF THE FRONT RANGE OF COLORADO. U. S. Dept. Agr. Cir. 929, 36 pp., illus.
(12) Lavin, Fred
1953. GUIDE FOR RESEEDING BURNED AND LOGGED-OVER PONDEROSA PINE LANDS IN THE SOUTHWEST. U. S. Forest Serv. Southwestern Forest and Range Expt. Sta. Res. Rpt. 10, 11 pp., illus. [Processed.]
(13) Pechanec, Joseph F., Stewart, George, and Blaisdell, J. P.
1954. SAGEBRUSH BURNING—GOOD AND BAD. U. S. Dept. Agr. Farmers' Bul. 1948, 34 pp., illus.
(14) Plummer, A. P., Hull, A. C., Jr., Stewart, George, and Robertson, J. H.
1954. SEEDING RANGELANDS IN UTAH, NEVADA, SOUTHERN IDAHO AND WESTERN WYOMING. U. S. Dept. Agr. Handbook 71, 73 pp., illus.
(15) Stark, R. H., Toevs, J. L., and Hafenrichter, A. L.
1946. GRASSES AND CULTURAL METHODS FOR RESEEDING ABANDONED FARM LANDS IN SOUTHERN IDAHO. Univ. Idaho Expt. Sta. Bul. 267, 36 pp., illus.
(16) U. S. Department of Agriculture.
1948. GRASS. U. S. Dept. Agr. Yearbook. 892 pp., illus.
(17) Weintraub, Frances C.
1953. GRASSES INTRODUCED INTO THE UNITED STATES. U. S. Dept. Agr. Handbook 58, 79 pp.

U. S. GOVERNMENT PRINTING OFFICE: 1955